the use of a current meter, but that other factors also come into play. Otherwise it would be difficult, for instance, to understand how certain pelagic species of fish (*Myctophum glaciale* and *M. Dofleini*, *Stomias boa*, etc.) can at all seasons occur in far greater quantities—have a maximum of density—in the Alboran Sea (the westernmost part of the Mediterranean, between Spain and Morocco) than either west or east of there, despite the fact that the surface layers are in constant movement towards the east. This is actually the case, as was first shown by A. V. Tåning and Vilh. Ege on the basis of material from the *Thor* expeditions. The *Dana* Expedition has proved the same thing. Comparatively few specimens occur west of Gibraltar and east of Oran, but in the Alboran Sea itself great quantities of all three species were found, so that the contents of a single net might show, for instance, more than 1500 specimens, especially *Myctophum glaciale*.

In conclusion I cannot refrain from emphasising the extreme importance an intensive study of the Straits of Gibraltar and adjacent waters would have for general—physical and biological—oceanography. When, at the commencement of October, I was obliged to leave this area in order to take up the other tasks allotted to the *Dana* Expedition, it was with the conviction that the expedition would in all probability have been able to do more for the cause of oceanography in general by keeping station at Gibraltar during the ten months we have for work, than by cruising about the ocean. Being so convinced, I venture to hope that British naturalists may soon take up this important task, which Great Britain, with Gibraltar as a base, has unique opportunities for dealing with. A research vessel stationed at Gibraltar would take but half an hour to arrive on the scene of operations, the meeting-place of two deep seas. The saving in time and coal, and the unparalleled opportunities of utilising all favourable weather conditions for oceanographical work, are self-evident.

(On board the *Dana*, at San Vicente, Cape Verde Islands, November 1, 1921.)

Photographic Studies of Heights of Aurora.

By Dr. C. Chree, F.R.S.

THE two publications referred to below,[1] by Prof. Carl Störmer, of Christiania, merit the attention of all interested in the physics of the atmosphere. As is generally known, Prof. Störmer discovered a satisfactory method of measuring the height and position of aurora by means of photographs taken simultaneously at the two ends of a long base. The photographs include two or more stars, the exact positions of which in space are ascertainable, the precise time of taking the photographs being known. The difference between the positions of the aurora relative to the stars in the two photographs enables the necessary calculations to be made.

The first memoir gives a very full account of photographs taken in the spring of 1913 at two Norwegian stations, Bossekop (B.) and Store Korsnes (K.), 27·5 km. apart, near latitude 70° N. Some of the results have been already discussed in a series of papers enumerated on p. 7, which have appeared in different publications, especially *Terrestrial Magnetism and Electricity*, the *Astrophysical Journal*, and the Paris *Comptes rendus*. But the present memoir, besides summarising these, contains much new matter. In chaps. 1 and 2, pp. 8–37, there is a description of the apparatus and equipment and of the methods of observation. This is intended to be supplementary to descriptions already given, but describes various improvements and simplifications. Chap. 3, pp. 38–156, is a complete journal in chronological order of all the 336 pairs of photographs discussed. Besides the date and hour and time of exposure, values are given of the parallax of each selected auroral point (*i.e.* the angle subtended at the point by the 27.5-km. base), its astronomical co-ordinates (altitude and azimuth), and several calculated data, including the height of the point above the ground, and the distance from Bossekop of the point itself and of the corresponding point on the earth's surface vertically under it. The vertical heights vary from 87 to 323 km., the horizontal distances from Bossekop from 5 to 780 km. Some of the more notable auroras are discussed in considerable detail. The 336 pairs of photographs appear in plates 1 to 28, each plate containing twelve B. (Bossekop) and the corresponding twelve K. (Korsnes) photographs. To each pair of photographs there answers a diagram showing the stars used in the calculations, the positions of the auroral points, usually distinguished by numerals, and dashed lines to represent the parallaxes.

We reproduce two pairs of B. and K. photographs. One (Fig. 1) represents an auroral curtain in which twenty-one points were measured. The nearest point (towards the apparent tops of the photographs) was at a horizontal distance of 99 km. from Bossekop, the most remote point (near the lower left-hand corner) at a distance of 265 km. The heights measured varied from 90 to 130 km. Fig. 2 represents a band having the right-hand edge exceedingly sharp and luminous. The twelve points measured are shown in the key diagram (Fig. 3). Their heights varied only from 102 to 108 km. The horizontal distances from Bossekop of points 1 and 12 were respectively 61 and 178 km., and their parallaxes were 13·1° and 7·7°. The stars used were α, β, and θ Aurigæ. C_1 and C_2 represent the positions relative to the stars of the centres of the plates for Bossekop and Korsnes. The other details as to the stars refer

[1] Carl Störmer: "Rapport sur une expédition d'aurores boréales à Bossekop et Store Korsnes pendant le printemps de l'année 1913." *Geofysiske Publikationer*, vol. 1, No. 5. Pp. 269+104 plates. (Kristiania, 1921.)

"Exemples de rayons auroraux dépassant des altitudes de 500 kilomètres au-dessus de la terre." *Geofysiske Publikationer*, vol. 2, No. 2. Pp. 5+2 plates. (Kristiania, 1921.)

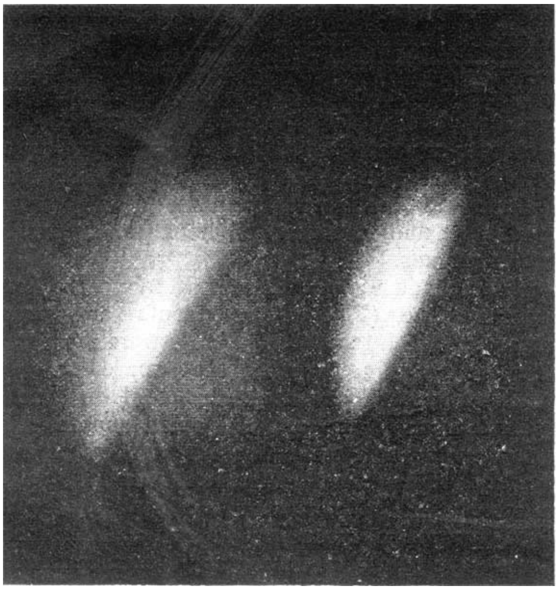


FIG. 1.—Auroral curtain photographed at Korsnes and Bossekop.

to the Bossekop photograph. The arrow-heads radiating from each star show the directions of the star's declination (δ) and altitude (*h*) circles and of the auroral parallax (*p*). The numerals 39, 43, 46 represent degrees of altitude. The azimuths of the stars, 180°–89·5°, etc., are also shown. The dotted lines represent the parallaxes in magnitude and direction.

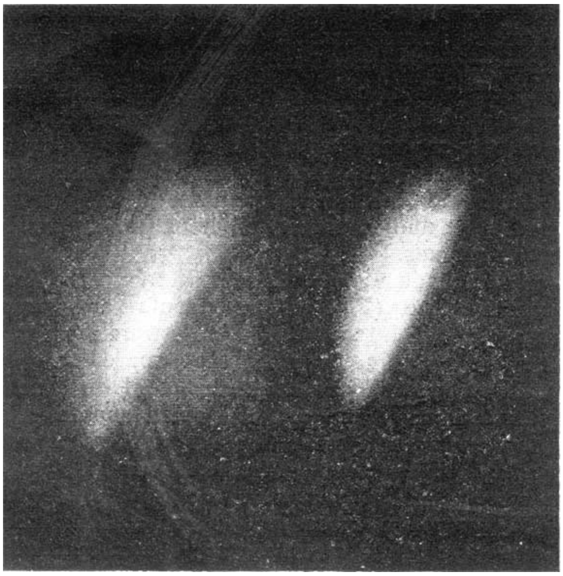


FIG. 2.—Auroral band photographed at Bossekop and Korsnes.

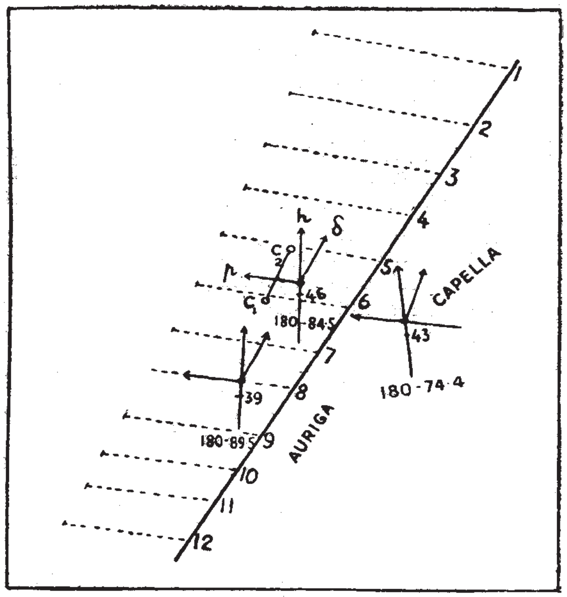


FIG. 3.—Measurements of points on Fig. 2.

The 336 key diagrams occupy plates 33 to 87. Finally, there are charts numbered 1 to 32, included in plates 90 to 104, which show the geographical positions of the points on the earth vertically under all the auroral points dealt with. The observational data are thus presented in an extremely systematic fashion. Chap. 4, pp. 157–212, includes a mathematical investigation of the variation in the inclination of the trajectory of an electrified corpuscle to the direction of magnetic force, the magnetic field having a potential. In the applications the earth's field is supposed to be given with sufficient accuracy by the first-order Gaussian terms. The corpuscle is supposed to have emanated from the sun, and its course is considered after it has come to within 500 km. of the earth's surface. The inclination of the trajectory to the magnetic lines of force tends to increase as the corpuscle approaches the earth. If the angle attains to 90° the corpuscle retreats. The energy may be absorbed while the corpuscle is approaching or while it is retreating, or some may remain after the retreat has carried the corpuscle outside the atmosphere. What happens is shown to be largely dependent on the constitution of the atmosphere. The author assumes that throughout the troposphere, the upper limit of which is put at 10·5 km., air is constituted exactly as at the earth's surface. But higher up in the stratosphere the several constituents, nitrogen, oxygen, argon, neon, helium, krypton, xenon, and hydrogen, behave independently. The author essentially follows Mr. Jeans, rejecting Wegener's hypothetical gas geocoronium. According to his calculations, p. 173, helium is the most important gas between heights of 110 and 200 km., hydrogen preponderating at greater, and nitrogen at lower, levels. These are practically the only gases that count when we consider how far down an auroral ray can come in the atmosphere. Separate calculations are made of the absorption of cathode and β-rays on one hand, and of α-rays on the other. A number of special cases are worked out for both positive and negative rays, and the luminosity at different heights is considered.

Chap. 5, pp. 213–222, comparing theory with observation, gives a brief analysis of the observed heights and contains some historical matter. The α-ray theory of aurora is credited to Prof. Vegard, who has now, however, abandoned it. The author's own conclusions seem, on the whole, in general accord with those now held by Vegard. He considers that the luminosity phenomena of aurora cannot be explained on the α-ray hypothesis except for what he calls "plaques pulsatoires." The most likely sources of all other auroras, he thinks, are cathode rays.

On pp. 221–22 is an interesting statement of what Prof. Störmer takes to be the auroral problems now calling for attention. The observational problems include height measurements in the Arctic and Antarctic, and the investigation of the auroral spectrum at different levels. The first theoretical problem remaining is to take account of the mutual electro-magnetic actions of the corpuscular currents, as well as of the action of the magnetic fields of the earth and sun. "On pourra alors . . . étudier jusqu'à quel point les objections de Shuster (Schuster) relatives à des faisceaux cathodiques dans l'espace sont bien fondées ou non." A second theoretical problem is to apply the knowledge we may gain of the auroral corpuscles to the study of solar physics.

The second paper by Prof. Störmer relates to auroral measurements made during a great magnetic storm on March 22–23, 1920. Use was made on that occasion of seven stations giving bases varying in length from 26 to 250 km. Of the heights measured, six exceeded 500 km., one being 607 km. The plates attached to the paper are enlarged negatives of the photographs obtained. The photograph reproduced here (Fig. 4) is a positive, which we owe to the kindness of Prof. Störmer. The demonstration of the existence of a sensible atmosphere at heights exceeding 500 km. is a notable event

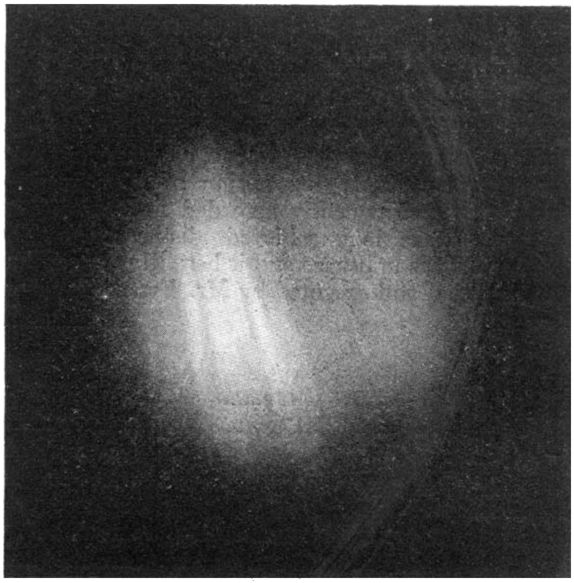
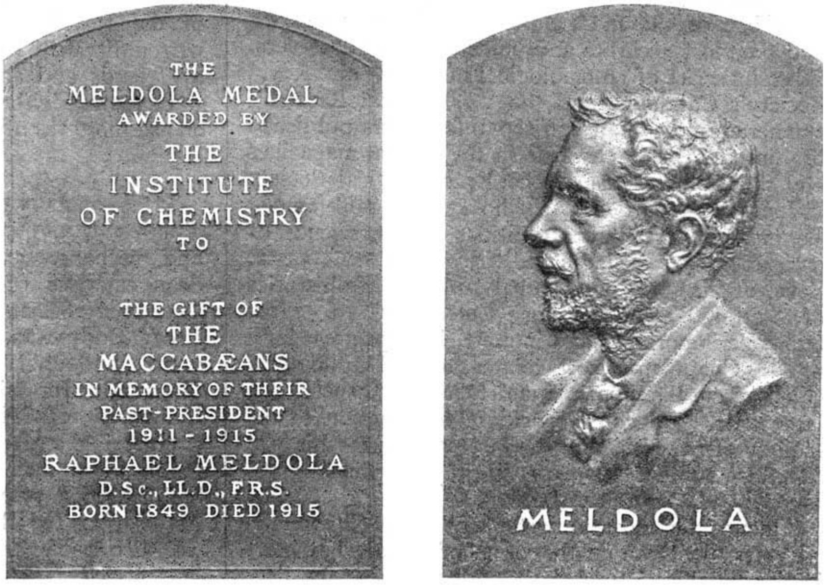


FIG. 4.—Aurora during the magnetic storm of March 22–23, 1920.

The Meldola Medal.

RAPHAEL MELDOLA was a man of remarkable versatility, eminent to an unusual degree in several sciences—chemistry, biology, entymology, astronomy—and of unbounded energy. How broad his sympathies and interests were, and how distinguished his services, should be sufficiently apparent from the fact that he was elected to the presidential chairs of the Essex Field Club, the Entomological Society, the Chemical Society, the Society of Dyers and Colorists, the Society of Chemical Industry, and the Institute of Chemistry. Apart from the distinctions connected with his scientific pursuits, Meldola was held in high honour among his own people as president of the Maccabæans, a society in London consisting mainly of Jewish professional men devoted to the promotion of the interests of the Jewish race.

That society has instituted a medal in order to perpetuate his memory, and has arranged with the council of the Institute of Chemistry that the



The Meldola Medal.